# Momentum:

- has to do with motion
- how much force you accumulate as you move
- force that keeps an object moving
- has to do with friction
- similar to inertia
- quality an object posseses that allows it to move in same direction at the same speed

## Momentum:

- intrinsic property of an object
  - ↳ base characteristic
- momentum = (mass)(velocity)
- $\bar{p} = m\bar{v}$
- Units: $kg \cdot m/s$
- We are concerned with a change in momentum:

$$\Delta\bar{p} = m\Delta\bar{v}$$

$$\Delta\bar{p} = m(\bar{v}_f - \bar{v}_i)$$

## Conservation of Momentum:

- Happens when "objects" collide

$$\Sigma \vec{p}_i = \Sigma \vec{p}_f$$

↳ Sigma, "sum of"

$$\vec{p}_{1i} + \vec{p}_{2i} + \ldots = \vec{p}_{1f} + \vec{p}_{2f} + \ldots$$

## Collisions:

- Three types:
  - Perfectly elastic
    - hit and bounce
    - never happens in real life
    - both energy and momentum are conserved
  - Combination of elastic and inelastic
    - Almost all real-world collisions
  - Perfectly inelastic
    - hit and stick
    - two objects start apart and then come together
    - two objects start together and then go apart

## Equations:

- Perfectly elastic:

$$\bar{p}_{1i} + \bar{p}_{2i} = \bar{p}_{1f} + \bar{p}_{2f}$$

$$m_1\bar{v}_{1i} + m_2\bar{v}_{2i} = m_1\bar{v}_{1f} + m_2\bar{v}_{2f}$$

- Perfectly inelastic:

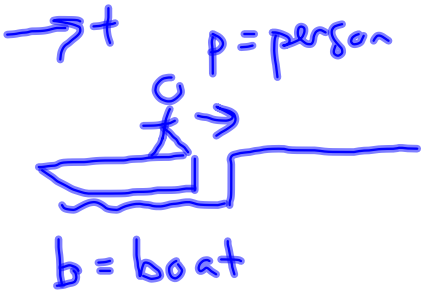
$$(m_1 + m_2)\bar{v}_i = m_1\bar{v}_{1f} + m_2\bar{v}_{2f}$$

$$m_1\bar{v}_{1i} + m_2\bar{v}_{2i} = (m_1 + m_2)\bar{v}_f$$

- All three equations are for one-dimension.

- Directions REALLY matter for the problems.

A 76 kg boater, initially at rest in a stationary 45 kg boat, steps out of the boat and onto the dock. If the boater moves out of the boat with a velocity of 2.5 m/s to the right, what is the final velocity of the boat?




$\bar{V}_i = 0$ m/s

$\bar{V}_{pf} = +2.5$ m/s

$m_p = 76$ kg $\quad m_b = 45$ kg

$\bar{V}_{bf} = ?$

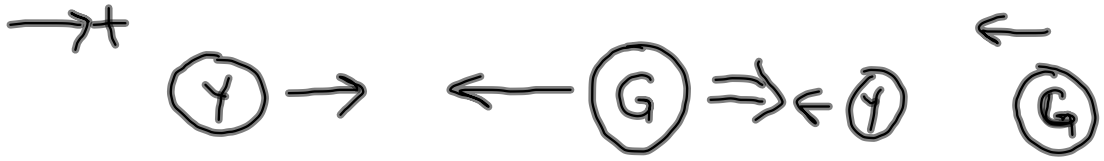
$$(m_p + m_b)\bar{V}_i = m_p\bar{V}_{pf} + m_b\bar{V}_{bf}$$

$$V_{bf} = \frac{-m_p V_{pf}}{m_b}$$

$$= \frac{-(76\text{ kg})(2.5\text{ m/s})}{(45\text{ kg})}$$

$$= -4.22\text{ m/s}$$

A 1.55 kg yellow sphere moving at 5.55 m/s to the right collides head-on with an 8.55 kg green sphere moving at 5.55 m/s to the left. After the collision, the green sphere is still moving to the left, but now with a speed of 3.25 m/s. What will the yellow sphere's velocity be afterward?




$V_{yi} = +5.55\ m/s$ $\quad V_{yf} = ?$

$V_{Gi} = -5.55\ m/s$ $\quad V_{Gf} = -3.25\ m/s$

$m_y = 1.55\ kg$ $\quad m_G = 8.55\ kg$

$$m_{yi}\bar{V}_{iy} + m_G\bar{V}_{Gi} = m_y\bar{V}_{yf} + m_G\bar{V}_{Gf}$$

$$V_{yf} = \frac{1}{m_y}\left[m_{yi}V_{iy} + m_G V_{Gi} - m_G V_{Gf}\right]$$

$$= -7.14\ m/s$$